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A NEW SPECIES OF TREMATODE
FROM THE MUSKRAT, *Fiber zibethicus**

With One Plate

BY FRANKLIN D. BARKER** and JOSEPH W. LAUGHLIN

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INTRODUCTION

On examining the contents of the alimentary canal of muskrats *Fiber zibethicus* which were shot on July 13, 1909, along the Loup river near Calloway, Nebraska, a large number of trematodes, representing several species, was found. A little later more muskrats were secured from the same place and examined and all were found to be infected with parasites, some of which were cestodes, others trematodes and still others nematodes.

At the suggestion of Doctor Barker, I began the study of these parasites of the muskrat and present the results of this study in the following paper.

The following table shows the number of muskrats examined, the parasites found and the organs infected.

*Studies from the Zoological Laboratory the University of Nebraska, No. 104.

**[It seems fitting that I should here state that the major portion of this investigation has been done by Mr. Laughlin working under my direction and he should therefore be given a large part of the credit for the work. I have carefully gone over all the data and have verified it by a study of the material and the slides used in this investigation.—
F. D. B.]

TABLE I
Parasites Found in Muskrats

Specimen Muskrat.	Parasite.	Organs Infected.	Number.	Date of Examination.
No. 1	Trematode A	Small intestine	8	
	Trematode B	Small intestine	100	7/13/09
No. 2	Trematode A	Small intestine	1	"
	Trematode B	Small intestine	4	"
No. 3	Trematode A	Small intestine	1	"
	Trematode B	Small intestine	2	"
No. 4	Trematode A	Small intestine	3	11/18/09
	Trematode B	Small intestine	5	"
	Cestode	Small intestine	1	"
No. 5	Trematode A	Small intestine	1	"
	Trematode B	Small intestine	26	"
	Cestode	Small intestine	1	"
No. 6	Trematode A	Small intestine	6	"
	Trematode B	Small intestine	8	"
No. 7	Nematode	Caecum	4	"
	Trematode A	Small intestine	1	"
	Trematode B	Small intestine	33	"
No. 8	Trematode A	Caecum	3	"
No. 9	Cestode	Small intestine	1	11/24/09
	Trematode A	Large intestine and Caecum	3	"
No. 10	Cestode	Small intestine	3	"
	Trematode B	Small intestine	14	"
	Trematode C	Caecum and large intestine	16	"
	Nematode	Caecum and large intestine	3	"
No. 11	Nematode	Caecum and large intestine	1	"
	Trematode A	Small intestine	2	"
	Trematode B	Small intestine	1	"
	Trematode C	Caecum and large intestine	11	"
No. 12	Trematode B	Small intestine	3	"
	Trematode C	Small intestine	65	"
	Nematode	Large intestine and Caecum	1	"
No. 13	Cestode	Small intestine	3	"
	Cestode	Small intestine	1	"
	Nematode	Small intestine	7	"
	Trematode B	Small intestine	6	"
No. 14	Trematode A	Small intestine	8	"
No. 15	Trematode A	Small intestine	1	"
	Trematode C	Large intestine and Caecum	2	"
No. 16	Trematode A	Caecum	3	"
No. 17	Trematode A	Caecum	5	"
	Trematode B	Small intestine	2	"
No. 18	Trematode A	Small intestine	4	"
No. 19	Trematode A	Small intestine	4	"
	Cestode	Small intestine	1	"
No. 20	Trematode A	Small intestine	1	"
	Trematode C	Small intestine	1	"
No. 21	Trematode A	Small intestine	1	"
	Trematode C	Small intestine	4	"
No. 22	Trematode C	Small intestine and Caecum	106	"
No. 23	Trematode A	Small intestine	1	"
	Trematode A	Small intestine	1	"
No. 24	Trematode A	Small intestine	2	"
	Trematode B	Small intestine	5	"
	Trematode C	Small intestine	1	"
No. 25	Trematode A	Small intestine	3	"
	Trematode B	Small intestine	4	"
No. 26	Trematode A	Small intestine	2	4/5/11
No. 27	Trematode C	Small intestine	2	"
	Cestode	Small intestine	1	"

TOTALS

Muskrats Examined.	Parasites Found.	Organ Infected	Number.
27	Trematode A	Small intestine and Caecum	64
	Trematode B	Small intestine	213
	Trematode C	Large intestine and Caecum	209
	Cestode	Small intestine	12
	Nematode	Large and small intestine and Caecum	16

It will be seen from the preceding table that the percentage of infection was very high, every muskrat examined being infected and that the degree of infection varied from 108 trematodes in muskrat number 1, to two trematodes in numbers 20 and 23. The table also shows that type A of the trematodes was found in the largest number of rats, namely twenty-two, or eighty-one per cent, while type B was found in fourteen, or fifty-one per cent, and type C in ten, or thirty-seven per cent. The table further shows that the cestodes were fewer in number but more widely distributed than the nematodes, cestodes occurring in twenty-nine per cent and nematodes in eighteen per cent of the muskrats examined. The small intestine harbored the largest number of parasites, the caecum less and the large intestine least of all. The stomach was entirely free from parasites.

The different types of trematodes vary greatly in size, type A measuring 30 mm and type C 3 mm, while type B was intermediate in length.

The three types designated as A, B and C represent three very distinct species and it is quite probable that a closer and more detailed study of those classed as type B will be found to represent more than one species. It is to be regretted that lack of time prevented me from making a detailed study of all the parasites found but this will be done later by other students in this laboratory.

As far as I have been able to learn from the literature, very little has been published on the parasites of the muskrat and the work which has been done is of a rather superficial nature.

TECHNIQUE

Two methods of killing and fixing were used. The first specimens were killed and fixed in 10% formol. They were taken from the muskrat, washed in normal salt, and then placed in a vial containing 10% formol and allowed to stand for twenty-four hours, and then transferred to 70% alcohol.

The remainder were killed in hot alcoholic corrosive-acetic solution. The trematodes were first washed in normal salt solution, then drained, and while still in the watch glass the hot corrosive was poured over them. These were allowed to stand in the corrosive

acetic for thirty minutes and were then transferred to 70% iodized alcohol.

Several stains were used:—haematoxylin, borax carmine, carmalum, eosin, and Wright's blood stain. Haematoxylin gave the best results in toto mounts. Wright's blood stain stained the finer ducts of glands well. Specimens were stained in toto in borax carmine for section work and the stain gave excellent results. Great care was necessary in clearing as it was impossible to clear in cedar oil or in xylol direct without producing great shrinkage. The best results were obtained when the specimens were taken from absolute alcohol to a mixture of absolute alcohol with 10% of xylol, to which xylol was added, a pipette full at a time, until a mixture largely xylol was obtained.

Fresh specimens mounted in glycerine proved very satisfactory for study as the various ducts showed very distinctly; this was especially true of the vas deferens and the vitelline ducts.

MORPHOLOGY OF TREMATODE *Notocotyle* *quinqueseriale* n. sp.

A lack of time prevented me from studying more than one of the trematodes obtained. The principal morphological features of the trematode designated as type C, which I have studied in detail, are as follows:

The body is pinkish in color, due possibly to ingested blood from the wall of the muskrat's intestine.

The shape of the body is that of a wedge tapering gradually from the posterior to the anterior end. The anterior end is tapering and the posterior end rounding, in some specimens slightly truncate. That portion of the body anterior to the uterus is more distensible than the posterior portion and in distended specimens has the appearance of a neck region. The dorsal surface is smooth and slightly convex while the ventral surface is concave and provided with five distinct longitudinal rows of wart-like projections or papillae which extend from the posterior to the anterior end of the body. Each row consists of from 16 to 18 distinct papillae, making 80 to 90 papillae in all. Plate I, figs. 1, 2, 6. The papillae vary somewhat

in size, but are all knob-like in shape, being set off from the body by a slight constriction. Plate I, figs. 1, 2, 6, 8, 9.

Sectioned papillae show that the uterus, vitelline glands, ovary and testes dip into them when they lie beneath these organs. Plate I, figs. 8, 9.

The rows of separate papillae constitute one of the most constant and distinctive external characters of the worm. The skin is smooth and without spines.

The worms vary in length from 2.5 mm to 4.0 mm, the mode being 3.0 mm, with 15% having this length. The minimum width of the body at its widest part, namely at the level of the ovary, is 0.66 mm, while the maximum width is 1.33 mm, the mode being 1 mm, with 45% having this width. The width is seen to be more constant than the length.

The oral sucker is at the anterior end, ventral in position and its musculature is strongly developed. The worms clung tenaciously to the walls of the intestine of the muskrat and it was necessary to use some force in pulling them away.

The length of the oral sucker (anterior-posterior diameter) varies from 0.20 mm to 0.416 mm, the mode being 0.30 mm, 27% having this length. The width varies from 0.216 mm to 0.450 mm, the mode being 0.333 mm, 38% having this width.

A pharynx is entirely wanting in this trematode. The mouth opens into a very short esophagus, so short in some specimens that it scarcely deserves the name. The esophagus divides into two intestinal caeca which run caudad on either side of the coils of the uterus; posterior to the uterus they turn mesad and then pass posteriorly between the ovary and testis on either side and end as blind sacs in the posterior end of the trematode. These tubes are simple and without secondary branchings and have nearly the same diameter throughout. Plate I, fig. 10.

The reproductive system in this form is quite complicated and extensive. Both male and female sexual organs are found in the same individual. The male genitals consist of two testes, vas efferens, vas deferens, seminal vesicle, pars prostatica, cirrus and cirrus pouch. The testes are located in the posterior fifth or sixth of the trematode, posterior to the uterus and one on either side of the ovary and lying

in the same plane. They are somewhat elongated and quite irregular in outline, due to their lobes, of which there are from five to eight. The lobes on the ventral surface extend into the ventral papillae which lie ventral to them. The texture of the testes is distinctly granular. Their length varies from 0.30 mm to 0.50 mm, the mode being 0.35 mm for 40%. Their width varies from 0.16 mm to 0.33 mm, the mode being 0.25 mm for 65%. The length is seen to be about twice the width.

From the inner side of the anterior border of each testis a short vas efferens passed cephalad and mesad. The two vas efferens unite near the shell-gland to form a large vas deferens, which passes cephalad in the median plane of the body and dorsal to the uterus until it reaches the anterior coils of the uterus where it turns to the right and after making one or two loops enters the cirrus-pouch in which it coils several times and then enters the seminal vesicle.

In some specimens the vas deferens lies ventral to the most posterior coils of the uterus but only for a short distance. Plate I, fig. 10.

The seminal vesicle is oval or pear shaped and varies in size according to the degree of distension by the mass of sperm cells. It lies at the base and within the cirrus pouch. Its walls are muscular, both circular and longitudinal muscle fibres being present. Anterior to the seminal vesicle lies a long and at first somewhat twisted tubular organ with glandular walls; this is the pars prostatica.

The seminal vesicle and the base of the pars prostatica are surrounded by a mass of glandular cells which form the prostate gland. The pars prostatica leads to a well defined cirrus, the walls of which are covered with blunt projections or spinelets which evidently aid in copulation.

The cirrus opens into a short genital sinus which in turn opens to the exterior thru the genital pore which is on the ventral surface in the median line about one-fourth the diameter of the oral sucker posterior to the oral sucker. Plate I, figs. 10, 11. The seminal vesicle, pars prostatica and cirrus are enclosed in a common cirrus-pouch. The terminal portions of the genital organs are seen to be

strongly developed which is a characteristic feature of the genus to which this form belongs.

The female reproductive organs are much more extensive than the male and more difficult to make out. The ovary is situated posterior to the uterus and shell gland and lies between the two testes and the ends of the intestinal caeca. Plate I, fig. 10.

The ovary is lobulated and very irregular in shape, which gives the edges an indented appearance. The ovary is about the same size as the testes, but in some specimens it is decidedly smaller. It lies in the same plane as the testes. Its maximum length is 0.50 mm, its minimum 0.20 mm, and the mode 0.25 mm for 33%. Its maximum width is 0.30 mm, its minimum 0.166 mm, and the mode 0.166 mm for 55%. The texture of the ovary is granular, having much the same appearance as the testes. The substance of the ovary projects into the ventral papillae as was mentioned in the description of papillae. A well defined shell gland lies immediately anterior to the ovary, occupying a dorsal position in the body. The anterior lobes of the ovary frequently overlap the posterior margin of the shell gland. The shell gland is oval or globular in shape and one-third to one-half the size of the ovary; its texture is coarsely granular but not as dense as the ovary and its contour is generally smooth and not markedly lobed like the ovary.

The vitelline glands are lateral in position, lying outside of the intestinal caeca on either side of the body, extending anteriorly from the level of the shell gland to, or within a short distance posterior to, the base of the cirrus-pouch. The glands on each side are made up of from ten to fifteen small globular or lobed acini which are fairly well defined and distinct, tho fusing in many instances. The acini on each side are connected by a longitudinal duct which passes along their inner side back to the most posterior acinus where it turns mesad and forms a transverse vitelline duct which passes to the shell gland and meets the vitelline duct from the opposite side, the two uniting to form a well defined vitelline reservoir which is slightly embedded in the ventral wall of the shell gland. Plate I, figs. 10, 11.

Neither in toto mounts nor in sections was I able to find any trace of a Laurer's canal.

The oviduct passes caudad from the ovary thru the shell gland, anterior to which it becomes the uterus. The uterus is voluminous, lying in close coils which vary in number and extend from the shell-gland to a plane a little anterior to the base of the cirrus pouch. The uterine coils occupy the median half of the body from side to side and the third fourth from the anterior end. The uterus lies between the intestinal caeca and is densely packed with eggs from the shell gland to a point a little anterior to the cirrus pouch where it becomes modified to form a long vagina. At the base of the cirrus pouch the uterus turns to the left and then passes caudad a short distance along the left side of the pouch and then becomes modified and forms a long thick-walled vagina, which lies to the left of the cirrus pouch and extends from a point near the base of the pouch to the genital sinus just posterior to the oral sucker. Plate I, figs. 10, 11.

Just before reaching the genital sinus the vagina passes under the cirrus pouch and runs along ventral to it until it terminates in the genital sinus. The walls of the vagina are thick and muscular, two sets of muscle fibres, circular and longitudinal being plainly visible. Plate I, fig. 7.

The eggs are of a light straw color and vary in size from 0.019 mm to 0.021 mm in length, the mode being 0.0195 mm, 37% having this length. Their width varies from 0.01 mm to 0.013 mm, the mode being 0.010 mm, 50% having this mode.

The eggs are further characterized by having a long polar filament at each pole. These filaments vary greatly in length from 0.031 mm to 0.26 mm, and one or both may be only rudimentary. At one end of the egg is a polar cap similar to that found in most species of trematodes. Plate I, figs. 3, 4, 5.

It was impossible to make out the entire excretory system but the study of toto mounts and sections showed the main features of the system. An excretory pore surrounded by muscle fibres is situated at the posterior end of the worm about 0.2 mm from the posterior end of the worm and in the median line on the dorsal surface. The pore opens from a Y-shaped excretory bladder lying just beneath it. The branches of the Y pass cephalad to the right and left of the ovary while the main stem passes caudad for a very

short distance and ends blindly. The excretory pore is just posterior to the fork of the branches. Anterior to the ovary the two branches appear to break up into a number of smaller branches which it was impossible to follow. Plate I, fig. 12.

Nothing was ascertained as to the life history of this trematode or the means of infection, tho a large number of snails, some living, was found in the stomach of the muskrats which suggests the possibility of snails being the intermediary host.

SYSTEMATIC POSITION

According to Braun's classification of the *Monostomidae* in Bronn's Klassen und Ordnungen des Thierreichs v. 4, p. 914, the worm which I have described would be classed in the genus *Notocotyle* Dies. by virtue of the five rows of longitudinal papillae which according to Braun distinguishes the genus *Notocotyle* from the genus *Ogmogaster* Jaegerskiöld, which is characterized by the possession of fifteen to seventeen long ribs (Längsrippen) on the ventral surface.

Braun's table of the genera constituting the family *Monostomidae* is as follows:

Nur vorderer Saugnauf.

Genitalporus vorn *Monostomum*

Genitalporus hinten *Opisthotrema*

Ausser dem Saugnauf noch.

Saugwarzen in 3 Längsreihen der Bauchfläche.. *Notocotyle*

15-17 Längsleisten auf der Bauchfläche..... *Ogmogaster*

Braun (ibid. p. 916) describes the genus *Notocotyle* as follows:

Monostomiden mit verlängertem oder ovalem, stark abgeplattetem Körper; Vorderende sich zuspitzend, Hintende abgerundet; Bauch fläche concav mit in Reihen angeordneten retractilen Warzen, auf den Drüsen ausmünden.

Mund öffnung subterminal, von einem Saugnapf umgeben; Oesophagus sehr kurz, Darmschenkel bis ans hintere Körperende reichend. Genitalporus hinter der Gabelstelle des Darmes; Geschlechtsdrüsen am hinteren Körperende; Laurer'scher Canal fehlt; Eier mit 2 fadenförmigen Filamenten. Leben in den Coeca der Vögel.

Diesing's (1850:411) original description of the genus is as follows:

Corpus oblongum depressum. *Caput* corpore continuum. *Os* subterminale anticum.

Acetabula numerosa (24-50) juxta totam dorsi convexiusculi longitudinem triseriata sessilia, orbicularia, limbo callosa. *Penis* ventralis superus longe spiralis. *Porus* excretorius ——— In avium intestinis crassis et coecis endoparasita.

Looss (1899:661) in discussing the genus *Notocotyle* holds that the rows of papillae on the ventral surface do not constitute a character of generic rank and to recognize them as such would place several species in the genus which have very different internal organizations, such as *M. verrucosum*, which has 3 rows of papillae and *M. proteus*, which has 7 or 8 rows. Looss, however, considers that *M. verrucosum* offers an arrangement of organs which can rightly be considered as a construction type and of generic value, and on this ground gives the following as the characters of the genus *Notocotyle*.

Monostomiden mit verlängertem, hinten breit abgerundetem, nach vorn etwas verschmälertem, flachem Körper ohne sichtbare Gliederung. Haut mit feinsten Stacheln besonders im Vorderkörper und auf der Bauchseite dicht durchsetzt. Der Saugnapf folgt dicht auf die Mundöffnung, Oesophagus kurz, Darmschenkel einfach, reichen bis ins Hinterende, *ohne sich daselbst zu vereinigen*. Excretionsblase wie bei *Cyclocoelum*, ihre Mundung bei Betrachtung von aussen als rosettenförmiges Organ erscheint. Genitalporus *median oder fast median, in der Nähe des Saugnaufes gelegen*. Begattungsorgane *vorhanden, lang gestreckt und dünn*. Der Cirrusbeutel *umschliesst einen Theil der Samenblase*, eine mehr oder minder entwickelte Pars prostatica, Ductus ejaculatorius und Penis; letzterer meist mit Knötchen oder Spitzchen besetzt. Hoden *symmetrisch, fast im äussersten Hinterkörper ausserhalb der Darmschenkel*; das gemeinsame Vas deferens bildet vor seinem Eintritt in den Cirrusbeutel eine in mehr oder minder zahlreiche Querschlingen gelegte *äussere Samenblase*. Keimstock *zwischen den Hoden*; Schallendrüsenscomplex vor ihm; Laurer'scher Canal *vorhanden*, Receptaculum seminis fehlt. Dotterstöcke mässig entwickelt, in den

Seiten und vor den Hoden gelegen. Schlingen des Uterus ziemlich regelmässig quer verlaufend die Darmschenkel nach aussen *nicht überschreitend*. Eier wenig gefarbt, mit langen Polfäden. Im Blindund Enddarm von Wasservögeln.

Typus: *Notocotyle verrucosa* (Froelich).

Looss gives the presence of spines as one of the external characters of the genus but no spines were found on the form from the muskrat. It will be seen that the inner organization of the form described agrees with Looss' description of the genus *Notocotyle* with one or two exceptions. No trace of Laurer's canal was found in the form from the muskrat nor is there a well defined ductus ejaculatorius, tho that portion of the male genital canal anterior to the prostate gland and just posterior to the cirrus, which was described as a part of the pars prostatica might possibly be considered as a ductus ejaculatorius.

Looss gives water birds as the hosts of *Notocotyle*, while the muskrat is a water mammal and thereby the range of hosts as well as the geographical distribution of the genus is extended.

The monostome found in the muskrat in many respects resembles *Ogmogaster phycatus* Creplin which Jägerskiöld (1891^a:127-134) (1891^b:1-16) has described as found in *Balaenoptera musculus* and *Balaenoptera borealis*. It differs, however, in having rows of ventral longitudinal papillae instead of the characteristic longitudinal ribs of *Ogmogaster*. The vitelline glands are also well developed in the form from the muskrat and as Looss (1899:663) points out, the vitelline glands are not so strongly developed in *Ogmogaster* as in *Notocotyle*.

Inasmuch as this monostome from the muskrat differs in many respects from the species of *Notocotyle* described up to this time it may be designated as a new species. One striking character which distinguishes it from the other species is the presence of five longitudinal rows of papillae on the ventral surface. This diagnostic character suggested the name *quintseriale* an appropriate specific name for this monostome from the muskrat, which I therefore designate as *Notocotyle quinqueseriale*.

I desire here to acknowledge my indebtedness and appreciation to Doctor Franklin D. Barker, of the Department of Zoology of the

University of Nebraska, who suggested this problem to me, and with whose helpful cooperation I have been able to complete this research.

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ABBREVIATIONS USED AND EXPLANATION OF PLATE

C, Cirrus	P. P, Pars prostatica
C. P, Cirrus pouch	S. G, Shell gland
Es, Esophagus	S. V, Seminal vesicle
E. P, Excretory pore	T, Testis
Ex. C, Excretory canal	Ut, Uterus
G. P, Genital pore	Va, Vagina
I, Intestine	Vd, Vas deferens
O. S, Oral sucker	Ve, Vas eferens
Ov, Ovary	V. G, vitelline gland
P, Papillae	V. Dt, Vitelline duct
P. F, Polar filament	V. Rsv. Vitelline reservoir
P. G, Prostatic gland	

PLATE I

All drawings were made with a camera lucida from original stained and mounted specimens.

- Fig. 1.—*Notocotyle quinqueseriale* Barker and Laughlin, ventral view.
 Fig. 2.—Cross section of body showing papillae.
 Fig. 3.—Eggs of *Notocotyle quinqueseriale* Barker and Laughlin.
 Fig. 4.—Egg with polar filaments and operculum.
 Fig. 5.—Egg.
 Fig. 6.—Longitudinal section of body showing papillae.
 Fig. 7.—Cross section thru cirrus pouch and vagina.
 Fig. 8.—Longitudinal section of papillae, showing invasion of uterus.
 Fig. 9.—Cross section of papillae.
 Fig. 10.—*Notocotyle quinqueseriale* Barker and Laughlin, ventral view.
 Fig. 11.—Ends of genital ducts.
 Fig. 12.—Posterior end showing excretory pore and canal.

